



**Drivers and Inhibitors of
Electric Vehicles**

Based on data from a live test fleet of electric vehicles

December 2011

MEC INTELLIGENCE[®]

For some time, Electric Vehicles (EV) have been a 'hot topic' due to growing environmental concerns and increased oil prices. Car manufacturers, consumers and governments alike - all have interests in the transition towards EV's.

Several major and small manufacturers have moved into the EV market space. Although, compared to conventional Internal Combustion Engine Vehicles (ICE), EV's have yet to capture the mass market due to several reasons. However, within a few years, it is believed that the market will experience a major accelerated growth.

This report highlights some of the most central drivers and inhibitors that influence the EV roll-out in terms of speed, adoption and acceptance.

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Introduction



This report seeks to highlight the central drivers and inhibitors that influence the roll-out of electric cars in terms of adoption speed, cost and user acceptance.

The report is largely based on data gathered and analyzed from a test fleet of electric vehicles, which was driven by families and public officials over a period of 12 months (2009 – 2010), in and around the metropolitan area of Copenhagen (Denmark).

This data has been analyzed by ‘Catalyst Strategy Consulting’ (with whom MEC Intelligence has a strategic partnership) - this report draws upon their findings.

The report published by Catalyst Strategy Consulting was funded by the Danish Energy Agency, as a part of their efforts to uncover the inherent predicaments of EVs being deployed. This report is freely available from both the website of Catalyst Strategy Consulting and that of the Danish Energy Agency.



In addition, this report is based on general market data, which has been analyzed and correlated with data from the test fleet mentioned above, along with in-house knowledge.

As the test fleet was located in Denmark, some of the data and analyses presented, have particular focus on the Danish market for electric vehicles – nonetheless, all data, analyses, findings and conclusions are relevant globally, where markets for electric vehicles are expected to play a role in transportation.

Introduction / Electric Powered Vehicles

There are predominant types of electrically powered vehicles: Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV) & Electric Vehicles (EV)

Hybrid Electric Vehicles (HEV):

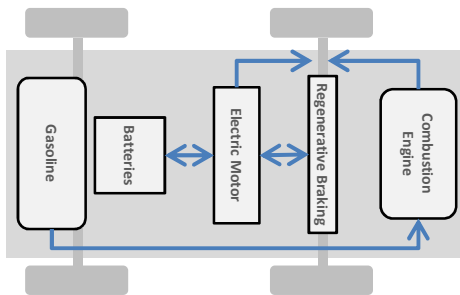
A hybrid electric vehicle uses both an electric motor and an internal combustion engine to propel the vehicle. The hybrid market is growing - there are a variety of hybrid electric vehicles available to consumers today, with more models on the way.

Advantages:

Reduced fuel consumption and exhaust emissions / Optimized fuel efficiency and performance / Lower fueling costs / Recovered energy from regenerative braking / Uses existing gas station infrastructure

Challenges:

Complexity of two powertrains (sources / engines) / Component availability - batteries, powertrains, power electronics / Higher initial cost.



Plug-in Hybrid Electric Vehicles (PHEV):

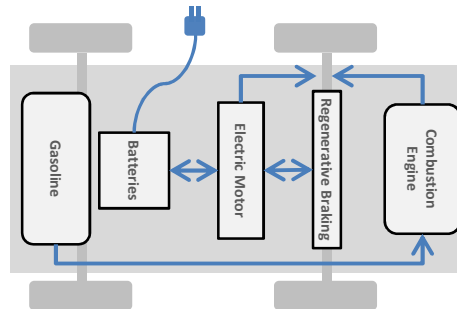
Plug-in electric vehicles come in many forms and configurations. Hybrids with plug-in capability use a combination of grid electricity, regenerative energy from braking, and power from another onboard source, such as an internal combustion engine or fuel cell.

Advantages:

Reduced fuel consumption and emissions / Recovered energy from regenerative braking / Unchanged gas station infrastructure / Grid connection potential / "Home based" battery recharging / Zero emission capability

Challenges:

Cost and complexity of two powertrains / Component availability - batteries, powertrains, power electronics / Cost of batteries / Added weight.



Electric Vehicles (EV):

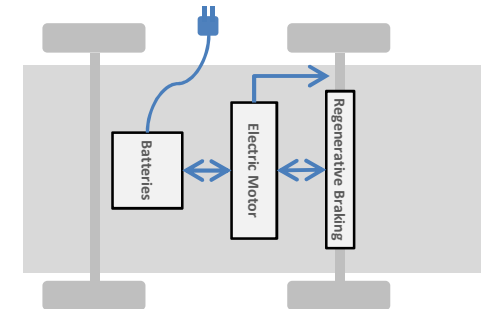
An electric vehicle uses batteries to power an electric motor to propel the vehicle and produce no tailpipe emissions. The batteries are recharged from the grid and from regenerative braking.

Advantages:

Zero emissions / Overnight battery recharging (by a standard household outlet.) / Lower fuel and operational costs / Possible use in secondary markets for used batteries and reduced waste

Challenges:

Improving battery technology: lower costs, increased energy density, extended durability, performance / Public recharging infrastructure / Extending range.



EV's are the least complex and the most efficient of the three, and far better than combustion engines

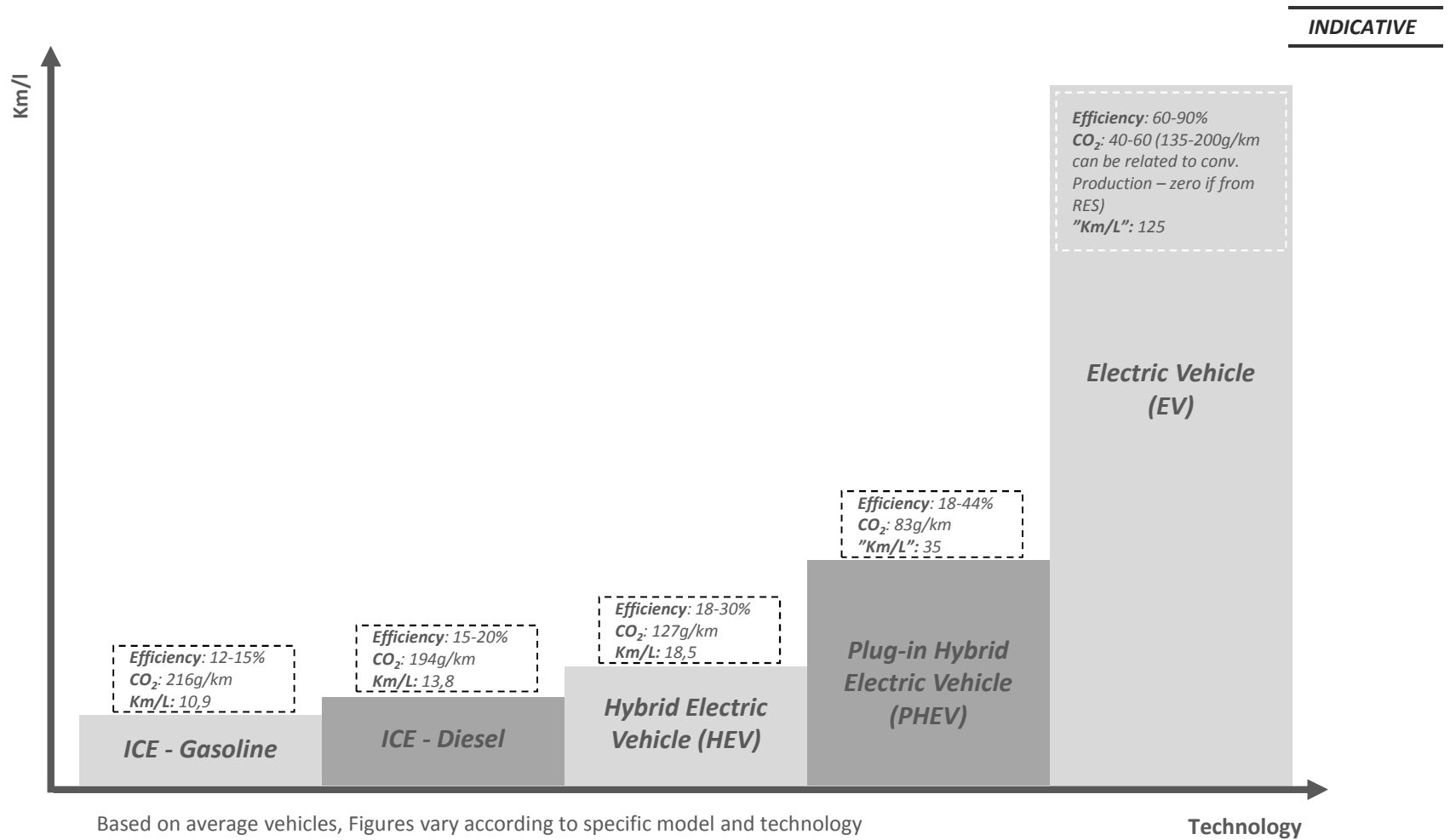


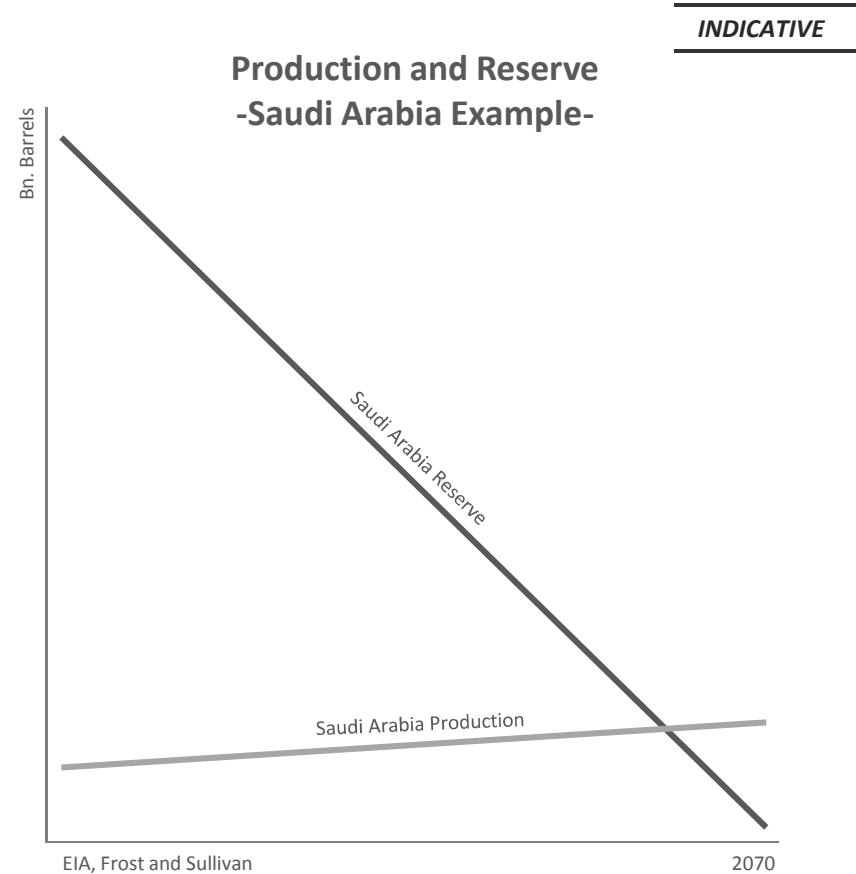
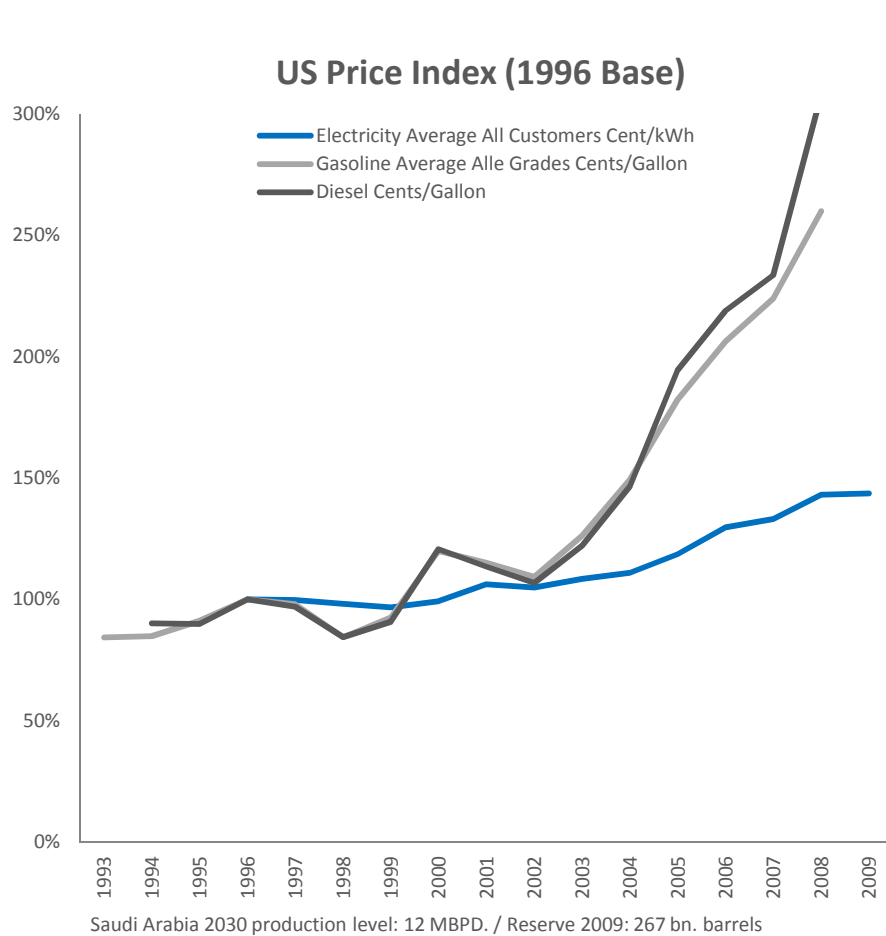
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Drivers & Inhibitors / Electricity prices are stable, while fossil fuel costs are rising

Electricity prices remain relatively stable, while fossil fuel costs are rising and reserves eroding



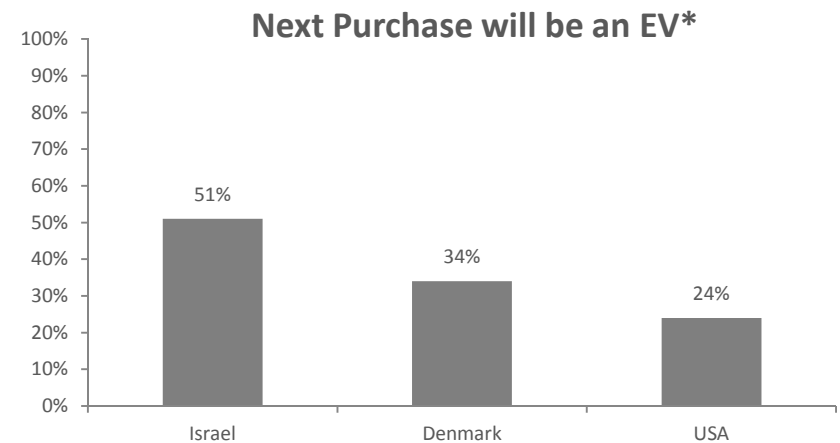
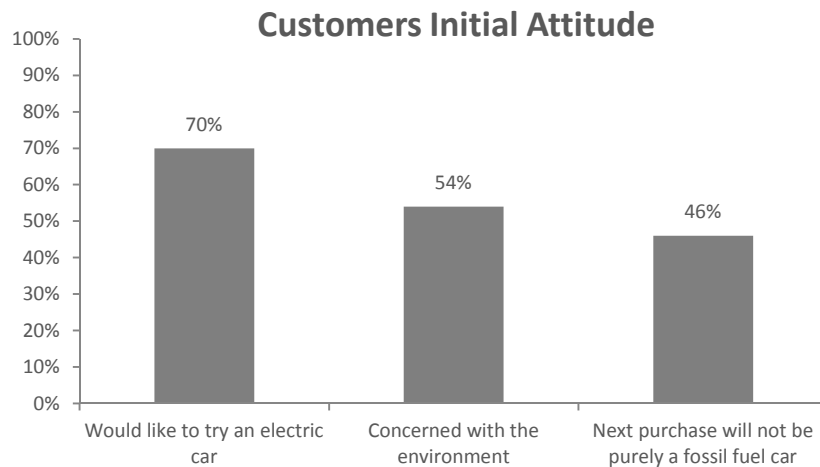
Drivers & Inhibitors / 40% consider purchasing a hybrid or electric as their next

70% of respondents would like to try an electric car, and over 40% consider to purchase either a hybrid or pure electric vehicle as their next car

ESTIMATE

Initial Survey

- Conducted by Better Place
- Marts to April 2009
- USA, Canada, Australia, Israel and Denmark
- 8.000 Respondents



Drivers & Inhibitors / Driving range and charging time are the most influential

High EV prices limit the current customer group to consist of primarily tech savvy and environmental ideologists, however new research indicates that charging time and driving range are among the most important factors influencing the purchase decision

Tech savvy and environmental ideologists

When new technologies are introduced, it is usually perceived as something uncertain and insecure. The magnitude of this technological insecurity, influences the adoption rate in the masses. The people driving the technology expansion are the so called 'lead users', such as the more tech savvy or environmental ideologists in the case of the electric vehicles.

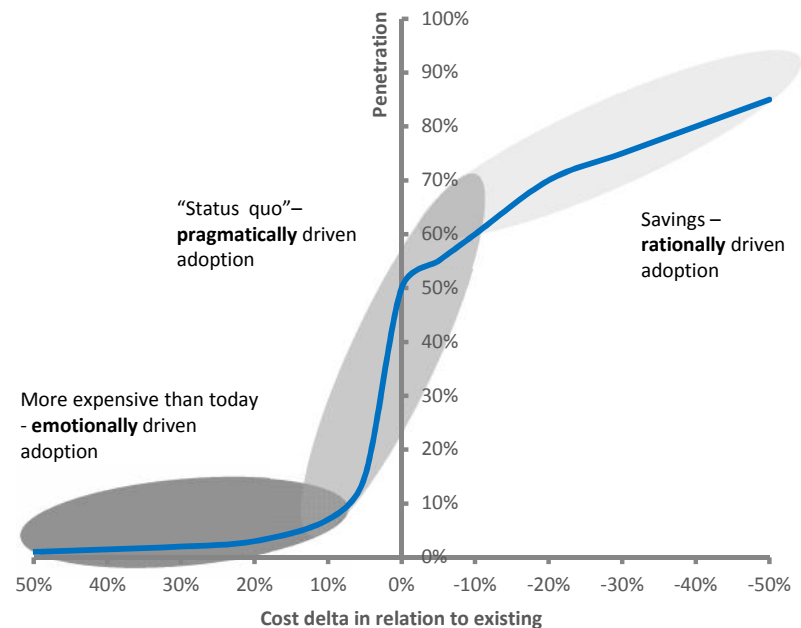
Charging time and driving range

New research suggests that while less than 1/5 of potential EV buyers prioritize price as the most important decision criteria, more people agree that charging time and driving range is important.

According to another new study (involving +3.000 American respondents) charging time and driving range is already acceptable for use in metropolitan areas. Industry experts agree that if enough marketing power is applied towards the right target group – there is a sizable market to explore already today.

Universal technology adoption curve
- Penetration vs. savings

INDICATIVE



Drivers & Inhibitors / EV leasing plans eases insecurity when considering a EV

EV leasing plans ease insecurity about investing in relatively new and unproven technology and infrastructure

	Drivers	Inhibitors
Purchase of EV and leasing of battery (Better Place)	<ul style="list-style-type: none"> • Exclusive provider of battery change • Economically attractive in the long run • Charging at Better Place chargers • Free charger for the home • Includes full service related to battery • Possible to alter leasing plan related to number of km. • Settlement per km. – not power usage • Exclusive provider of Renault Fluence Z.E. (at current) 	<ul style="list-style-type: none"> • Large investment in EV (excluding battery) residual value is unknown • Economically unattractive (in the medium and long run) • Only one EV brand and model is offered • Large costs related to establishing battery exchange stations • Doesn't include full car service • Subscription plan built on limitation of X km.
Leasing of EV and battery (ChoosEV)	<ul style="list-style-type: none"> • 36-48 months contract = risk reduction for user • Small investment up front = low risk • Economically attractive , with a short and medium term perspective • Access to ChoosEV and public chargers • Includes a free charger for the home and full car service • Possible to alter leasing plan related to number of km. • Exclusive provider of level 3 chargers (fast charger) • Offers a verity of EV's 	<ul style="list-style-type: none"> • Economically unattractive (in the long run) • Subscription plan with a limitation of X km. • Requires subscription to access certain exclusive charging stations
Purchase of EV and battery	<ul style="list-style-type: none"> • Economically attractive , with a medium and long term perspective • Freedom to choose any EV • No plan limits related to km. • No fixation period 	<ul style="list-style-type: none"> • Economically unattractive (short term) • High risk • Only access to public charging stations • Doesn't include charging station for the home or any service deals
Other factors	<ul style="list-style-type: none"> • Price erosion related to battery prices • Expansion of charging infrastructure • Larger variety of EV's in the coming years • Technological progress related to battery technology 	<ul style="list-style-type: none"> • Connection fee for using private charging stations • Lack of charging infrastructure in general • Political stand still or resistance towards progressing the roll out of EV's

Overall assessment of main drivers and inhibitors

Generic Inhibitors

- Existing mental models
- No predominant industry standard (dominant design)
- Lacking communication and control protocols
- Current designs
- Insufficient variation in product portfolio – does not allow for individualism or diversification

EVs

- Significant battery costs (20% of car)
- Immature technologies and limited range (+ long recharge time)
- Inconveniency in fuelling/recharging
- Performance
- Safety (risk of fire etc.)
- Wide infrastructure need

PHEVs

- Weight
- Cost
- Registration fees
- Complexity in two engines
- Uncompetitive pricing due to taxation of two engines (in some countries)
- Not truly green compared to EVs

Generic Drivers

- Rising fuel costs
- Dependence on instable states
- Environmental awareness
- Eco-trendiness
- RES integration potential
- Significant market opportunity in all associated categories (communication, charge points etc.)

EVs

- Pro-active taxation policies in some countries
- Performance potential in 4WD and torque
- Extremely efficient
- True zero emission potential

PHEVs

- Extended range potential / no risk of running low
- Little / no inconvenience
- Reduced infrastructure need
- Very efficient
- Well known technology for ICE component
- Multiple stakeholder satisfaction (from enthusiasts, consumers, auto makers to utilities and oil majors)

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Drivers & Inhibitors / (A) Pricing / EV prices across various countries

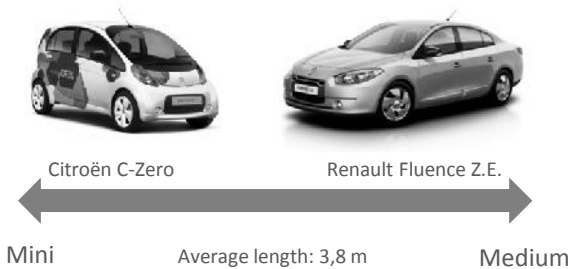
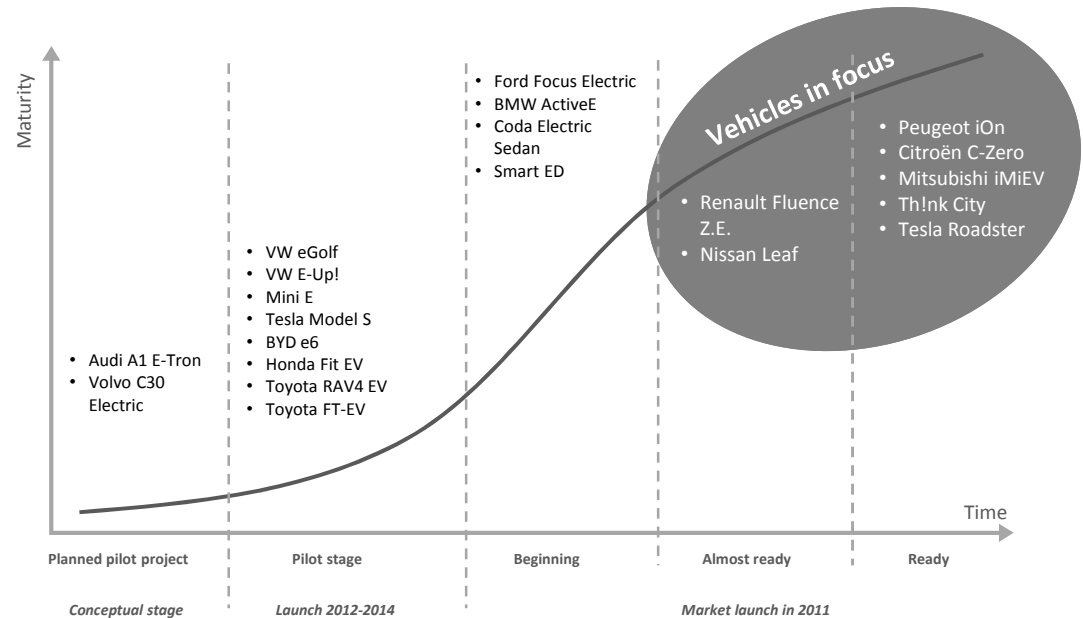
In order to compare EV prices across various countries, focus is placed on the most mature and common factory EV's on the global market today - the chosen EV's are all categorized as 'small to medium'

INDICATIVE

The selection criteria is, amongst others, related to market status in DK and vehicle type

Between 2011 and 2013, most major manufacturers plan to offer some type of EV to one or more market segments

To ensure applicable price comparison data, all EV's used, for the this analysis, are vehicles offered on the market today



Manufacturer	Model	Class	Launches in DK
Renault	Fluence Z.E.	Medium	October 2011
Nissan	Leaf	Medium	Summer 2011
Citroën	C-Zero	Mini	On market
Peugeot	iOn	Mini	On market
Mitsubishi	iMiEV	Mini	On market
Th!nk	City (2 seats)	Mini	On market
	City (4 seats)		
Tesla	Roadster	Sports car	On market

Drivers & Inhibitors / (A) Pricing / EV's - more than you would pay for a similar ICE

The chosen EV's are priced between ~200.000 – 300.000 DKK in Denmark, which is a great deal more than you would pay for a similar ICE alternative

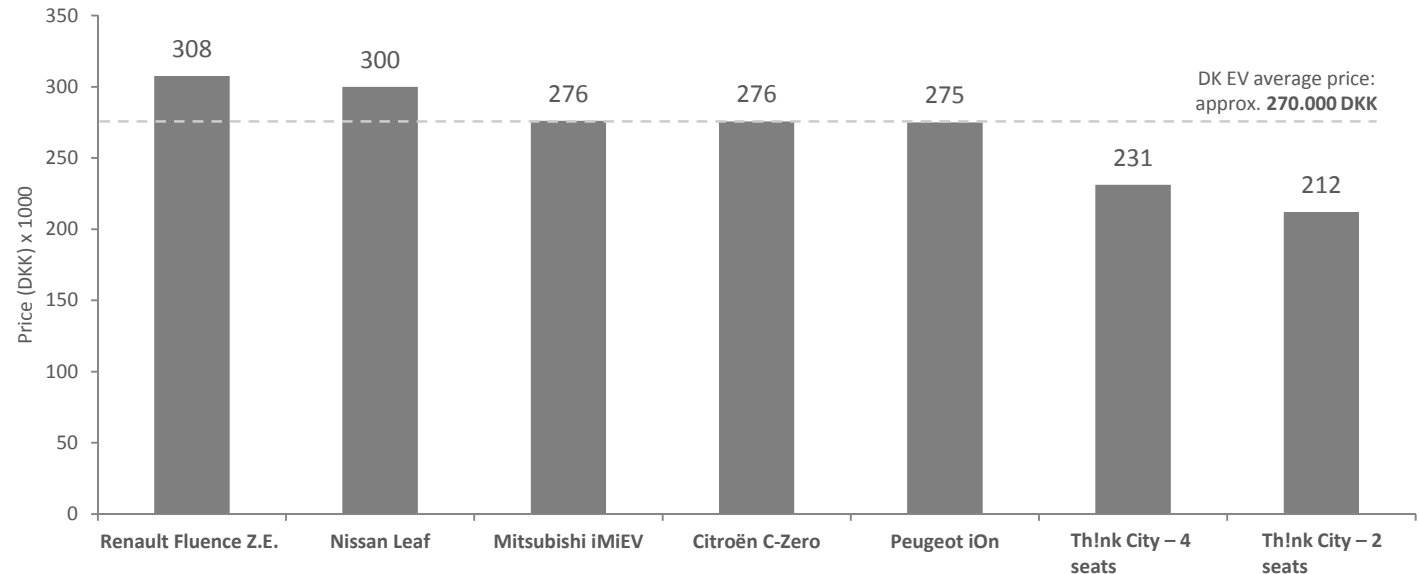
ESTIMATE

According to a recent survey* - about 17% are willing to pay 20 to 40 percent more upfront for an EV

The average price from the chosen EV's is approx. 270.000 DKK***

To meet the current challenges of the present charging infrastructure - the EV market is dominated by light cars in the 'mini category'. This is to ensure light weight cars that will drive longer per charge.

Price comparison of Danish EV's



- To compare EV prices appropriately, all cars are battery inclusive**.
- The price comparison doesn't involve cars that are converted from ICE to EV – such as Fiat 500E or Citroën EV'ie.

Source: Catalyst Strategy Consulting analysis based on data from manufacturers' websites (20-04-2011)

*IBM Institute for Business, survey: 'The shift to electric vehicles - Putting consumers in the driver's seat'

**Renault Fluence Z.E. isn't sold with a battery – so the complete price with battery is estimated on comparison terms from the car battery industry.

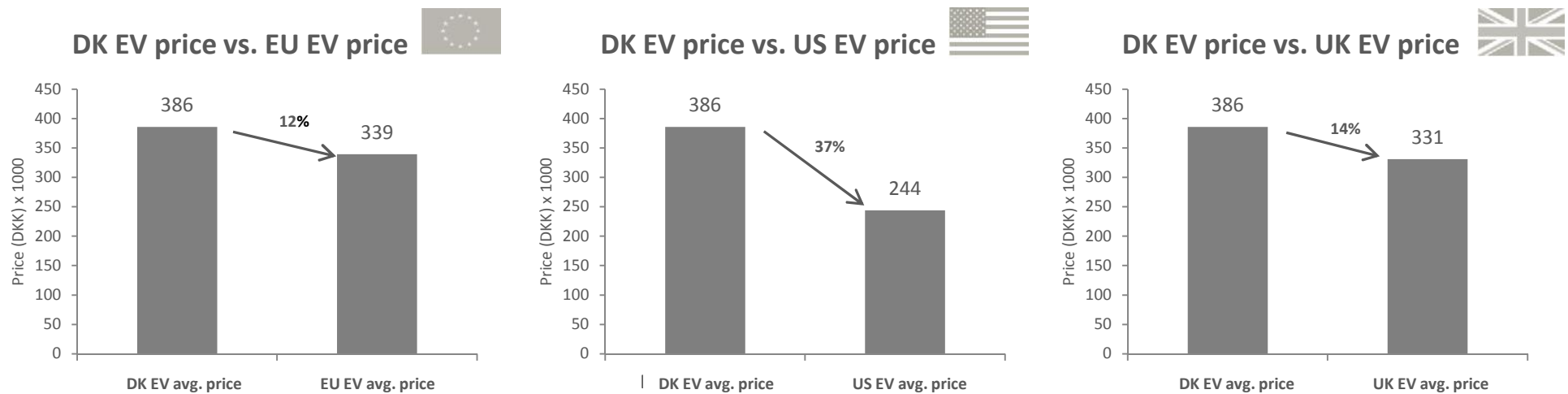
***Prices are excluding charging stations.

Drivers & Inhibitors / (A) Pricing / EV's are cheapest in the US compared to EU and UK

EV's are cheapest in the US compared to EU and UK - this is due to differences in VAT, import taxes, variations in components and power infrastructure

ESTIMATE

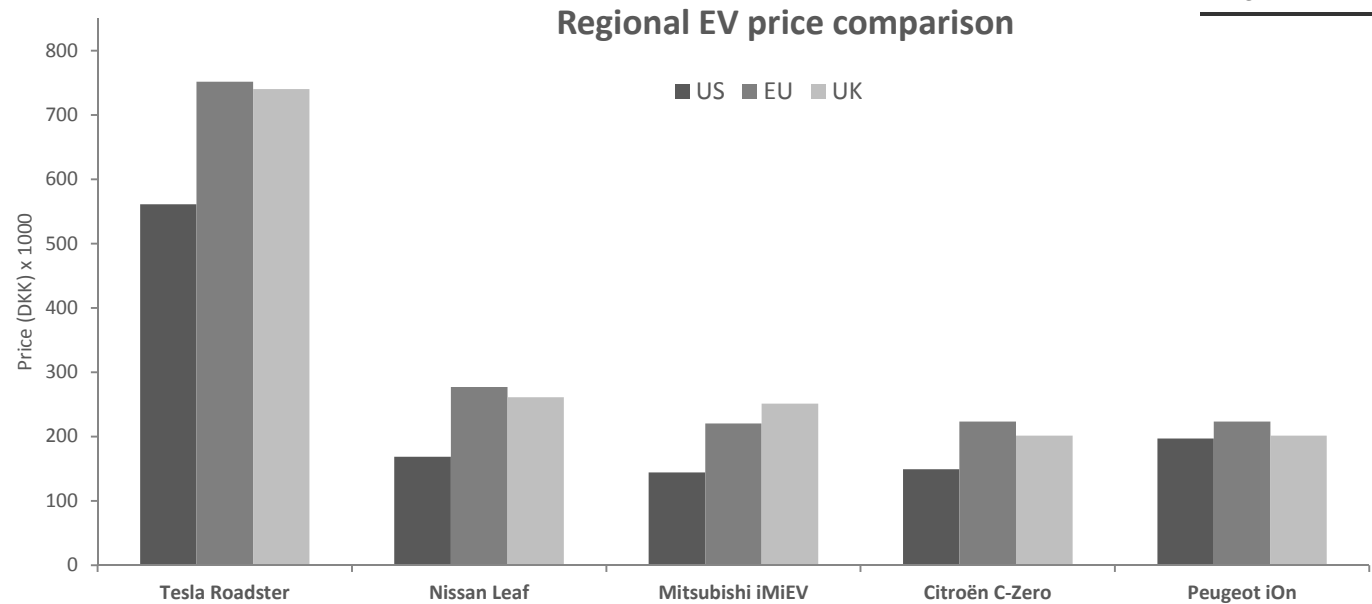
- In general, EV's are cheapest in the US.
- E.g. EV's are approximately 37% cheaper in the US compared to Denmark.
- And compared to EU and UK – between 12-14%.



Across all analyzed cars, US prices are the lowest – EU prices are generally the highest of the three

Mitsubishi iMiEV is approx. 70% more expensive in the UK compared to the US.

Besides VAT, import taxes and shipping costs – local guaranty and insurance plans very greatly in price.



Price differences are to some extent influenced by various subsidies (see below is a overview):

SVE:	SEK 40.000 "Supermiljøbilspremien" no road tax or congestion charge
UK:	£5.000 government electric car grant scheme
US:	\$7.500 government electric car tax credit
HOL:	€6.000 no vehicle registration fee or road tax
POR, IRE:	€5.000 vehicle registration initiatives

Source: Catalyst Strategy Consulting.

Renault Fluence Z.E. and Th!nk City do not figure in the price comparison as it wasn't possible to gather sufficient global price data.

Prices are based on basis models with a minimum spec configuration. Prices depend on exchange rates and registration differences. US do not apply VAT. Dependent on states, US applies sales taxes, car taxes or use taxes.

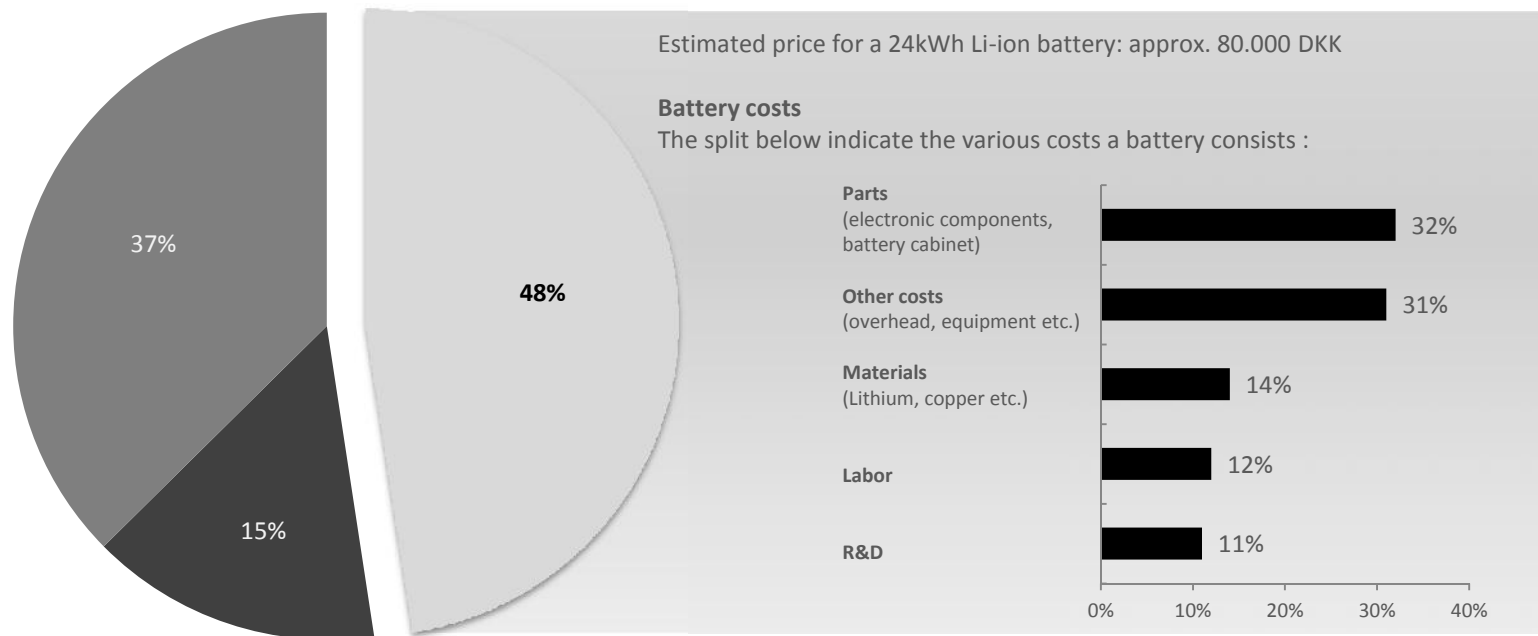
In general this price comparison used the lowest vehicle prices on the various markets where data has been gathered from.

Drivers & Inhibitors / (A) Pricing / Batteries account for 48% of the total EV sales price

Today, batteries account for approx. 48% of the total price of an average EV (US) - a breakdown indicates, that there is potential for 'scale of production', and thereby a consumer price reduction

ESTIMATE

Price breakdown of the Nissan Leaf (EV) based on US price: 170.000 DKK



- Li-ion battery
- EV components (engine, controller, electronics)
- Generic components EV's have in common with ICE

Price vs. costs

The cost breakdown does not show the profit split of the total EV price. As a result, the profit is an implicit part of the three "pie pieces" from the diagram. It has not been possible to deduce the profit by it self.

Drivers & Inhibitors / (A) Pricing / Battery prices are expected to halve over the next ten years

EV battery prices are expected to drop 50% over the next ten years due to increased EV demand and technology development - as a result, EV prices will become more competitive to ICE

ESTIMATE

Conservative scenario

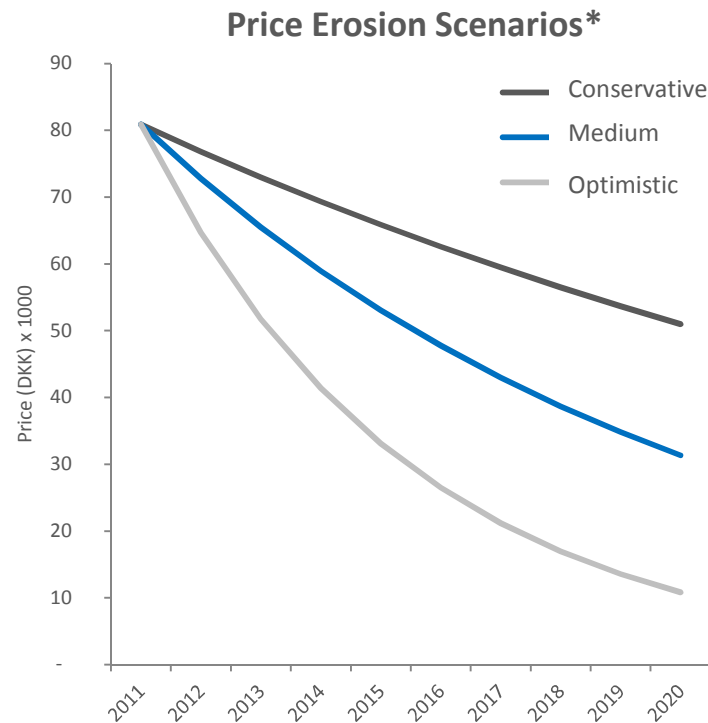
Based on opinions from a number of experts that do not expect a significant price erosion (~5% reduction per year) on Li-ion batteries

Medium scenario

Significant price erosion in the region of ~ 10% reduction per year ***.

Optimistic scenario

History from the consumer electronics industry indicates a strong price erosion of up to 20% reduction per year.



Li-ion batteries are expected to fall in price due to development, increased volume, economies of scale and especially due to interconnection of multiple batteries.

In terms of technology trends it is worth mentioning semi-solid rechargeable Lithium batteries** to be influential on a lower price.

It seems fair to assume that price erosion on EV Li-ion batteries will figure somewhere in between the optimistic and conservative scenario. E.g. an estimated battery price between 20.000-40.000 DKK in 2020.

According to the medium scenario, Li-ion battery price will deduct approx. 5.500 DKK per year and 1kWh will fall from 3.400 DKK to 1.300 DKK in 2020.

Source: Catalyst Strategy Consulting

*Forecasting is based on the latest data from the Nissan Leaf 24kWh Li-ion battery.

**Advanced Energy Materials – "Semi-Solid Lithium Rechargeable Flow Battery", MIT, 05.20.2011

***Deutsche Bank study

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Drivers & Inhibitors / (B) Charging / Charging stations are expected to undergo a big price erosion

Charging stations are expected to undergo a relatively aggressive price erosion in the coming years - stations are still relatively expensive to implement which restricts mass penetration of EV's

INDICATIVE

**Erosion case on public level 2 charging stations:
cost = component and software cost + installation + profit margin.**

As a result of maturing technology and economies of scale – component and software costs for charging stations are expected to reduce by 20% before 2015.

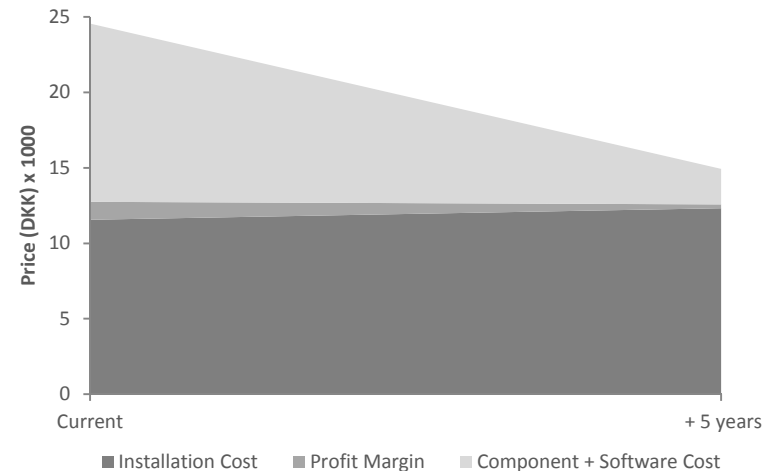
Profit margins account for about 10% and is expected to be unchanged.

Installation costs vary according to location and are expected to increase marginally as a result of inflation.

Manufacturers are still in the early phases of R&D in relation to technology, planning of pilot projects and commercial expansion in general. Manufacturers are uncoordinated and develop solutions (standards) to solve the charging infrastructure challenges.

As a result, solutions are still somewhat expensive and limit the necessary charging infrastructure. This affects and limits the roll out of EV's, as users will not accept less comfort related to driving distance than they have grown accustomed to in the past.

Charging station cost erosion

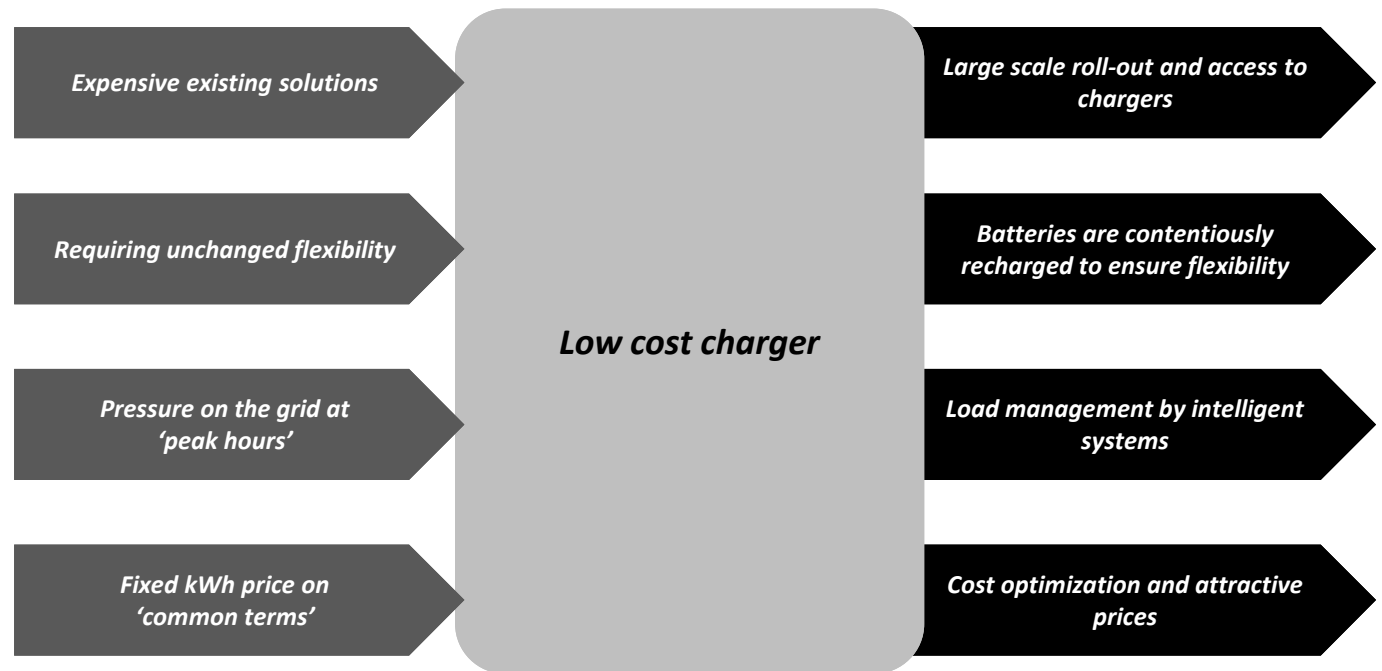


- Average installation costs is anticipated at 11.560 DKK
- Component and software costs is calculated to be the average of level 2 charging stations (DKK 8.670-17.340) subtracted profit margin
- Inflation rate for Denmark in 2011 was 1,3% - and is expected to be stable (1,3%) the next 5 years

To motivate mass adoption of EV's – the industry needs cheaper charging stations to meet customers demand for unchanged comfort and security in relation to 'charging everywhere'

To meet the users desire for charging – it's essential to develop a low cost charging solution / technology to motivate end encourage the development and progression of a broad charging infrastructure.

It is also essential for the charging infrastructure to become "intelligent" – in order to even out charging times at peak hours, where the electrical grid is under maximum strain.



Drivers & Inhibitors / (B) Charging / Actors plan to expand the charging infrastructure

Leading industry players plan to expand the charging infrastructure to help motivate more EV's on the road - slow adoption of EV's could result in a withdrawal of such plans

Status of public and semi public chargers in Denmark*:

- **All in all, 150 level 2 (slow chargers) are installed in DK. Of those approx. 100 are public and 50 are semi public and private (workplaces and such)**.**
- **The Danish capital of Copenhagen, plans to install approx. 500 charging stations between 2010 and 2011**.**
- **As of the moment Copenhagen has but one level 3 (fast charger) installed.**

<i>Company</i>	<i>Charging Stations Installed</i>	<i>Planned Installments</i>
<i>Coulomb Technologies</i>	<i>600</i>	<i>4.600 (US by 2011)</i>
<i>Elektromotive</i>	<i>500</i>	<i>1.000 (UK by 2011)</i>
<i>SemaConnect</i>	<i>N/A</i>	<i>80 (US by 2011)</i>
<i>RWE</i>	<i>240</i>	<i>800 (14 countries by 2011)</i>
<i>Better Place</i>	<i>60 + 1 battery station</i>	<i>800 (DK by 2011) 20 battery stations (DK by 2012)</i>

Other actors of interest:

GE / GridPoint / ABB / Itron / Siemens AG / Cleancharge / ChoosEV / eVgo (NRG Energy) / 350 Green / Salto ladestasjoner (collaborating with Statoil Norway)

Source: Catalyst Strategy Consulting

*Does not include charging stations in private homes.

**Report on legal conditions related to installment of EV charging stations, and infrastructure related to charging stations in the public space, (January 2011).

The two dominating charging methods are ‘plug in charging’ and ‘battery replacement’ - various support concepts such as Network Software, Smart Grid and Smart Meters integrate these with the electrical grid

	Elements	Concept Description	Companies
Charging Concepts	Charging Stations	<ul style="list-style-type: none"> Standing Platform Wall Mount Road side charging stations, parking areas and houses	<ul style="list-style-type: none"> Better Place Elektromotive RWE Coulomb Tech. SemaConnect
	Battery Changing Stations	Works like a “gas station” for EV’s that are manufactured to comply with the standard	<ul style="list-style-type: none"> Better Place – (in DK together with the energy provider “DONG Energy”)
Support Functions	Electricity Network Software	<ul style="list-style-type: none"> Monitoring of batteries in the infrastructure, charging status and expected energy demand Real-time communication with energy companies Charging management between network nodes and charging stations 	<ul style="list-style-type: none"> Better Place Elektromotive Microsoft Hohm SemaConnect Coulomb Tech.
	On-route computer platform	<ul style="list-style-type: none"> Warning by low voltage level Route planning Remaining charging time Closest charging station 	<ul style="list-style-type: none"> Better Place EV OEM
	Smart Grid and Smart Meters	<ul style="list-style-type: none"> Measurement of energy usage Intelligent management based on profile data and price signals 	<ul style="list-style-type: none"> Siemens Gridpoint Vattenfall

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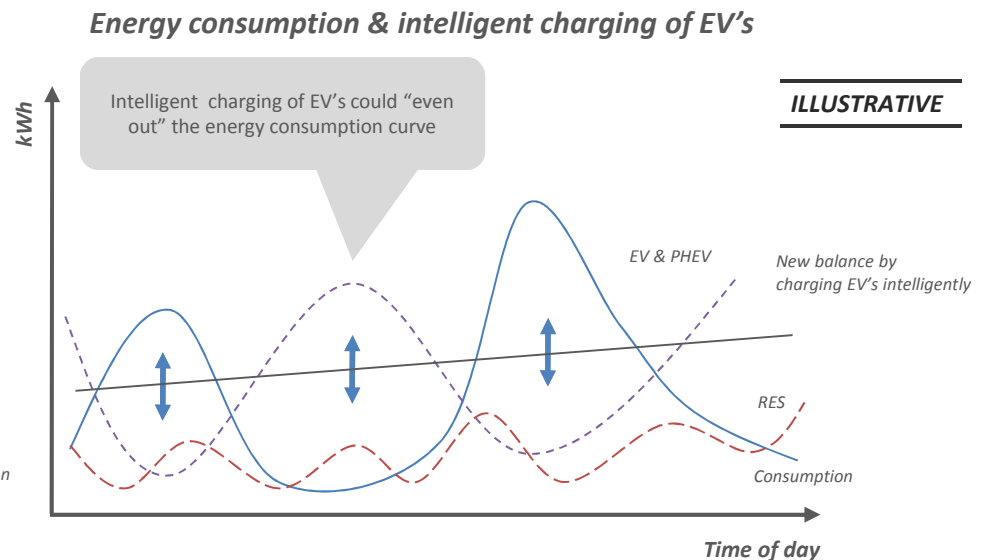
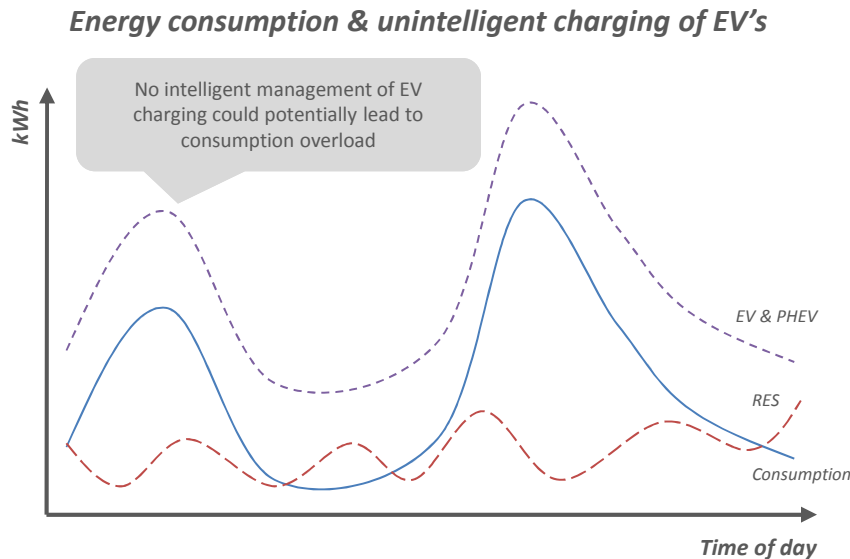
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Intelligent power grid management (Smart Grid) is necessary to avoid overloading the electrical grid at peak hours when charging EV's

Consumers of energy has a similar daily pattern in terms of power distribution. In morning and evening hours people use more energy than during day and night hours. This puts a lot of stress on the electrical grid at certain peak hours. Furthermore, during day and night hours, when energy consumption is at its lowest, energy production facilities (running at minimum capacity) sometimes have to sell off excess energy with a profit loss.

EV batteries has a somewhat large energy storage capacity, and as more EV's take to the road, the larger the combined battery storage capacity. This combined capacity can have both negative and positive effects on the electrical grid. Negative effects occur when all EV's charge during peak hours, which puts more pressure on the grid, leading to higher energy prices. To avoid this scenario, a intelligent charging infrastructure (like Smart Grid) is necessary to manage power distribution for charging EV's – charging them at hours outside peak periods when power consumption and power prices are low. This scenario could potentially “even out” the energy consumption curve – leading to better prices and lower losses related to excess energy production.



Too much 'fast charging' of EV's will erode 'Renewable Energy Source' integration and system optimization, as demand becomes unpredictable

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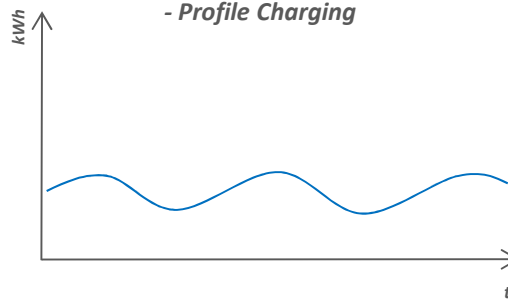
Profile Based

Profile Based Charging

Grid is utilized e.g. 90% by profile charging, and e.g. 10% to 'on demand' fast charging.

- Predictable consumption patterns, based on historic data
- Ability to influence consumption via incentives, e.g. price reduction in high capacity periods
- High potential for 'Renewable Energy Source' integration and system optimization

Predictable Consumption Pattern and Electricity Demand - Profile Charging



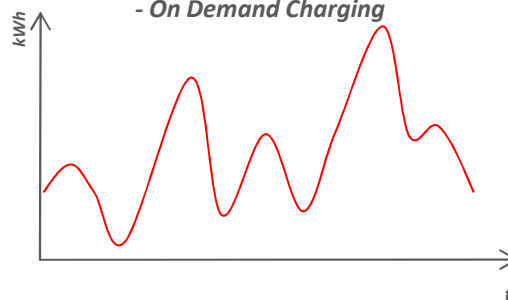
On-Demand Based

On-Demand Based Charging

Grid is utilized e.g. 50/50 for profile based charging and 'tank-station' on demand fast charging.

- Highly unpredictable consumption patterns
- High need for reserve capacity
- No equilibrium between supply and demand, means high opportunity cost or expensive additional electricity purchases in the marketplace

Unpredictable Consumption Pattern and Electricity Demand - On Demand Charging



Creating a predictable EV charging pattern will improve the optimization potential of the electrical grid.

To harness the full potential of renewable energy sources - initiatives to "smoothen" the charging demand of EV's are critical.

I.e. wide access to charge stations will play an essential role in surpassing the need for rapid on demand vehicle charging.

Drivers & Inhibitors / (C) Electrical Grid / Vehicles needs to be 'plugged-in' at all times when parked

To avoid excessive infrastructure investments (integrating EV's on the electrical grid) vehicles needs to be 'plugged-in' at all times when parked

In a future where EV's represent a substantial percentage of personal vehicles on the road – the electricity demand and consumption will rise accordingly. If all EV's were to charge at 'peak hours', the electrical grid would most likely not be able to cope with the extensive pressure.

Renewable energy sources are ideal to power our future EV's, as a supplement to conventional power production, and would relive the electricity grid of some pressure.

Integrating renewable energy sources with the power and charging demands of EV's – requires a intelligent electrify grid (e.g. Smart Grid) to allow intelligent charging of EV's. One of the major assumptions required to make intelligent charging possible – is for the EV's to be "plugged in" at all times when parked. The grid would then automatically charge the vehicle when e.g. there is a low of excess wind energy or outside 'peak hour' electricity consumption periods. The consumer should of course have the opportunity to manually "overwrite" the system for a immediate charge.

It is most likely that the user would need some kind of strong incentive to motivate a behavior towards remembering "plugging in" when parked. E.g. this could be a financial reward and punishment model.

Drivers & Inhibitors / (C) Electrical Grid / Agreeing on a common standard may prove difficult

Not all electrical distributors possess comprehensive knowledge and competences to manage the infrastructure roll-out - moreover, agreeing on a common standard and protocol may prove difficult

For the benefit of a future EV mobility infrastructure, it's likely that organizations (e.g. EU) will be given mandate to decide on one specific interface standard. This would enable all vehicles (across make and model) to utilize the same hardware.

To enable intelligent charging through Smart Grid – it's also likely that a united communication standard (protocols and algorithms) will be chosen to ensure alignment between the 'Transmission System Operator' and 'Distribution System Operator'.

Having agreed on a common hardware and software platform, it's still highly unlikely that manufacturers and vendors will chose the same technical components and applications to build there products. As a comparison, look to the cellular phone industry where manufacturers and vendors are free to conduct their products and solutions as they see fit – as long as the comply with the agreed infrastructure standard (NMT/GSM/3G).

Ensuring a dynamic charging capability (through Smart Grid) would imply electricity consumers to use multiple 'Distribution System Operators'. As a consequence it will be necessary to install more than one energy meter on charging installations. It would also require the consumer to have more than one energy meter at their private residence.

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Disclaimer

Central drivers and inhibitors that influence adoption, acceptance and roll-out speed of the electric vehicle has been explored in the previous sections.

The following section sums up by presenting and analyzing a real life test case based on data gathered from a fleet of electric vehicles. The test fleet was driven both by families and public officials over a period of 12 months (2009 – 2010) in and around the metropolitan area of Copenhagen (Denmark).

Disclaimers related to data from the test fleet:

- A limited part of the EV fleet was used by families and private purposes. Therefore the data has its limitations displaying a representative picture related to how private persons use EV's – (who most likely will represent the majority of EV users in the future).
- The data represents 37 EV's – which is a relatively small population in terms of data sources. Therefore the data gathered is not enough to draw any general conclusions. Rather the data, analysis and conclusions are of indicative nature.
- Data is subject to possible errors related to raw data gathered and collected from the test vehicles. Random raw data (samples) has been inspected to ensure validity. Also actions have been taken to identify and remove as much obvious "error data" as possible.
- It has been necessary to perform certain calculus 'triangulations' to make up for specific incomplete data.

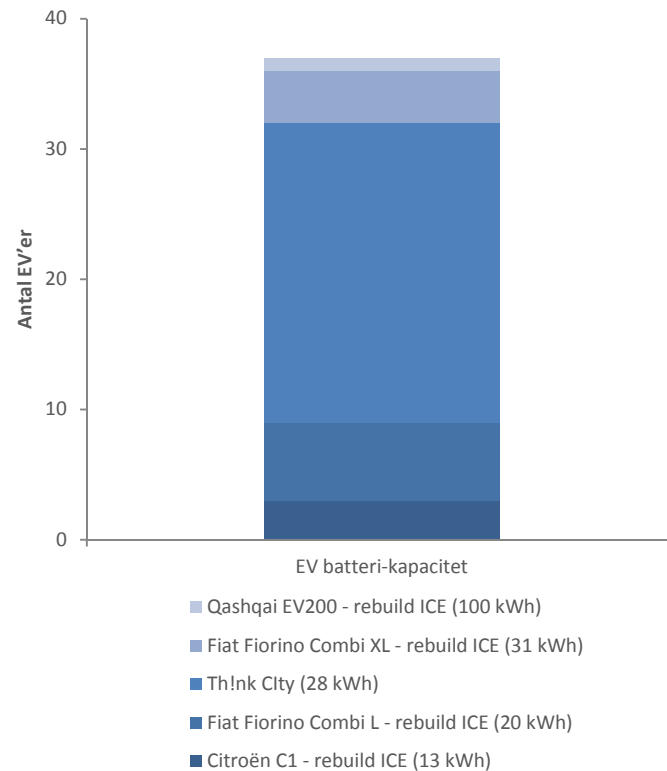
Data overview - Statistical data analyzed from a Danish test fleet of EV's - driven from 2009 to 2010

The represented data is from an experiment involving 37 'small car' EV's. The experiment was performed over a year (2009 - 2010) and funded by a Danish governmental organization called 'Energistyrelsen' (ENS).

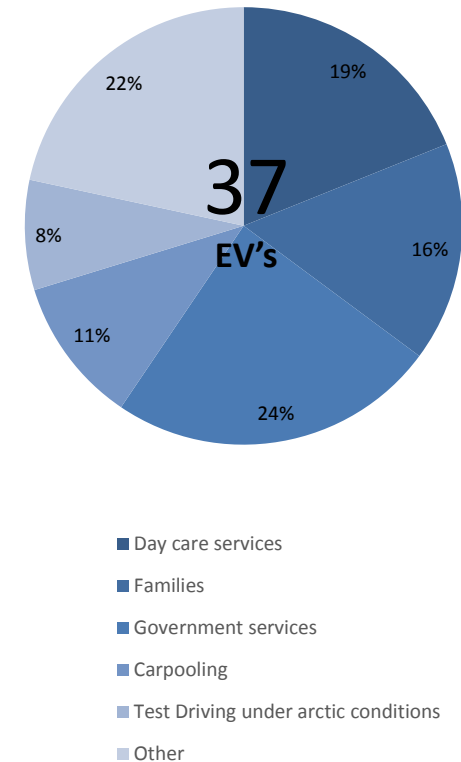
Charging method used by all EV's was "unintelligent" – meaning charging to 100% when plugged in.

The fleet primarily consisted of the vehicle type 'Th!nk City' – with a battery capacity of 28 kWh. Secondary a number of various rebuild ICE vehicles.

EV models and battery capacity



EV driving purposes



Results From Test Fleet / EV's utilize approx. 35% of the battery capacity

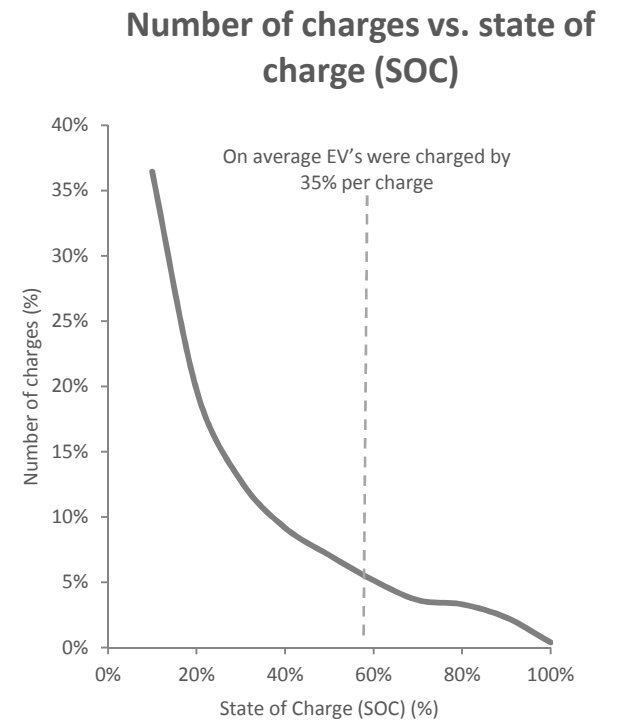
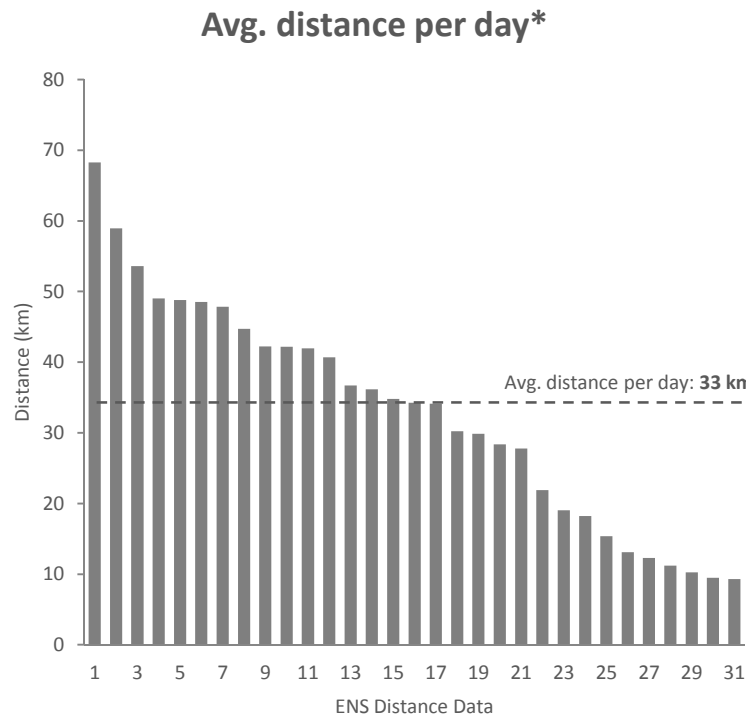
EV's drove an average of 33 km. per day – utilizing the battery by approx. 35%

EV's drove an average of 33 km. per day.

The longest distance per day averaged 68 km. and the shortest 9 km. per day.

EV's featured in this case have been driven over an average of 54 days. (with a minimum of 15 and maximum of 147).

On average EV's were charged by 35% per charge. In other words – batteries have a unused capacity of approx. 65% state of charge (SOC).



Results From Test Fleet / 68% of EV's were charged once daily

By every fourth parking, EV's were connected to a charger. And 68% of EV's were charged only once daily

68% of the test vehicles charged once daily – and 19% charged twice daily.

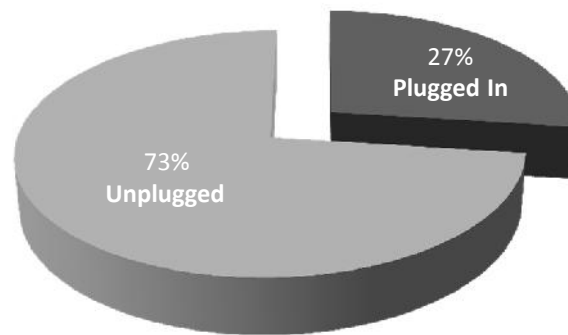
As shown on the previous slide, the average 'State Of Charge' (SOC) were 65%.

Users therefore have plenty of energy, sufficient for the daily need of most people.

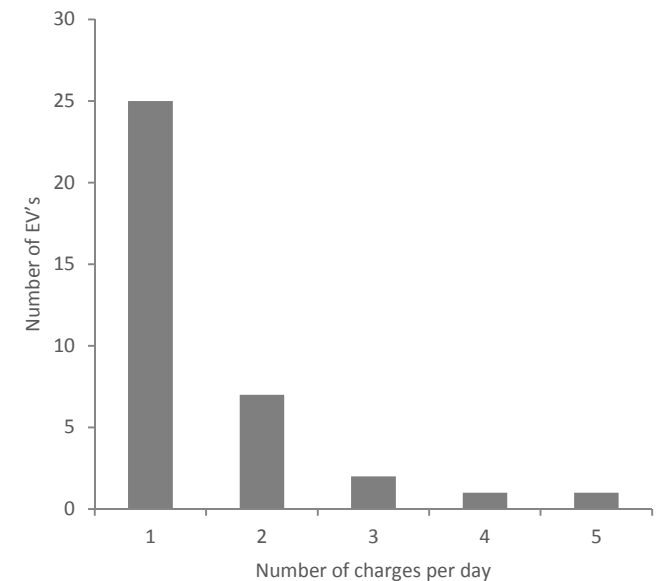
As a consequence, users can easily drive for a couple of days without charging.

Therefore users have no real incentive to 'plug in' to a charger when parked.

Charging pattern* of EV's



Number of charges per EV a day

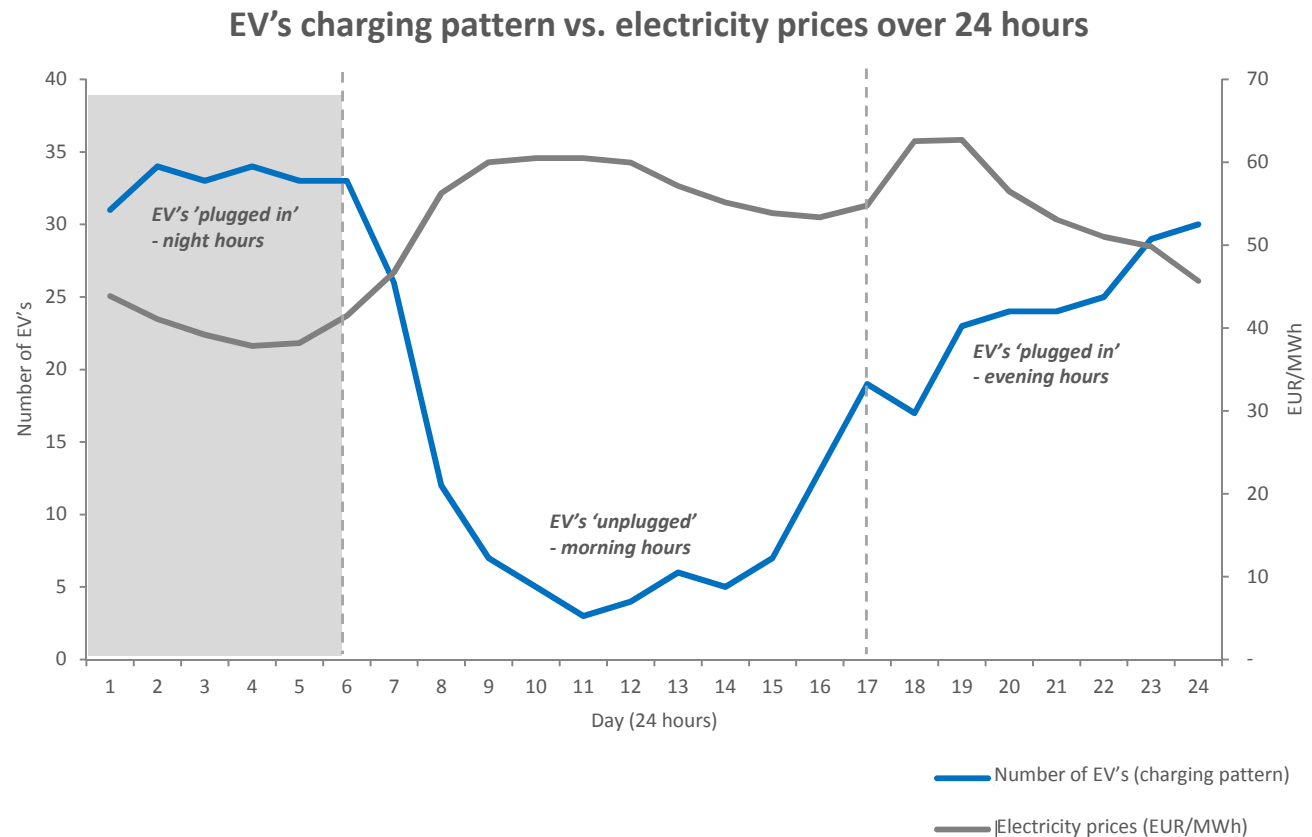


Results From Test Fleet / EV's charged during evening and night hours

The majority of EV's were 'plugged in' to a charger during evening and night hours - during this time frame, power consumption and power prices are the lowest – as such supply and demand potential have a good fit – given the utilization of smart grid / control

The majority of EV's were 'plugged in' to a charger during evening and night hours – and were 'unplugged' during morning hours.

The charging pattern represents data from situations where EV's charged more than 5% on one charge. This is to avoid and exclude situations of regenerative braking.



Results From Test Fleet / EV charging placing pressure on grid at “peak hours”

Without intelligent charging the majority of EV’s would charge between 5 pm and 9 pm - placing significant pressure on the power grid at ‘peak hours’

Intelligent charging could “even out” energy consumption by delaying charging until after ‘peak hours’ (symbolized by the grey area on the graph).

Charging during night hours when consumption is at it’s lowest would be ideal.

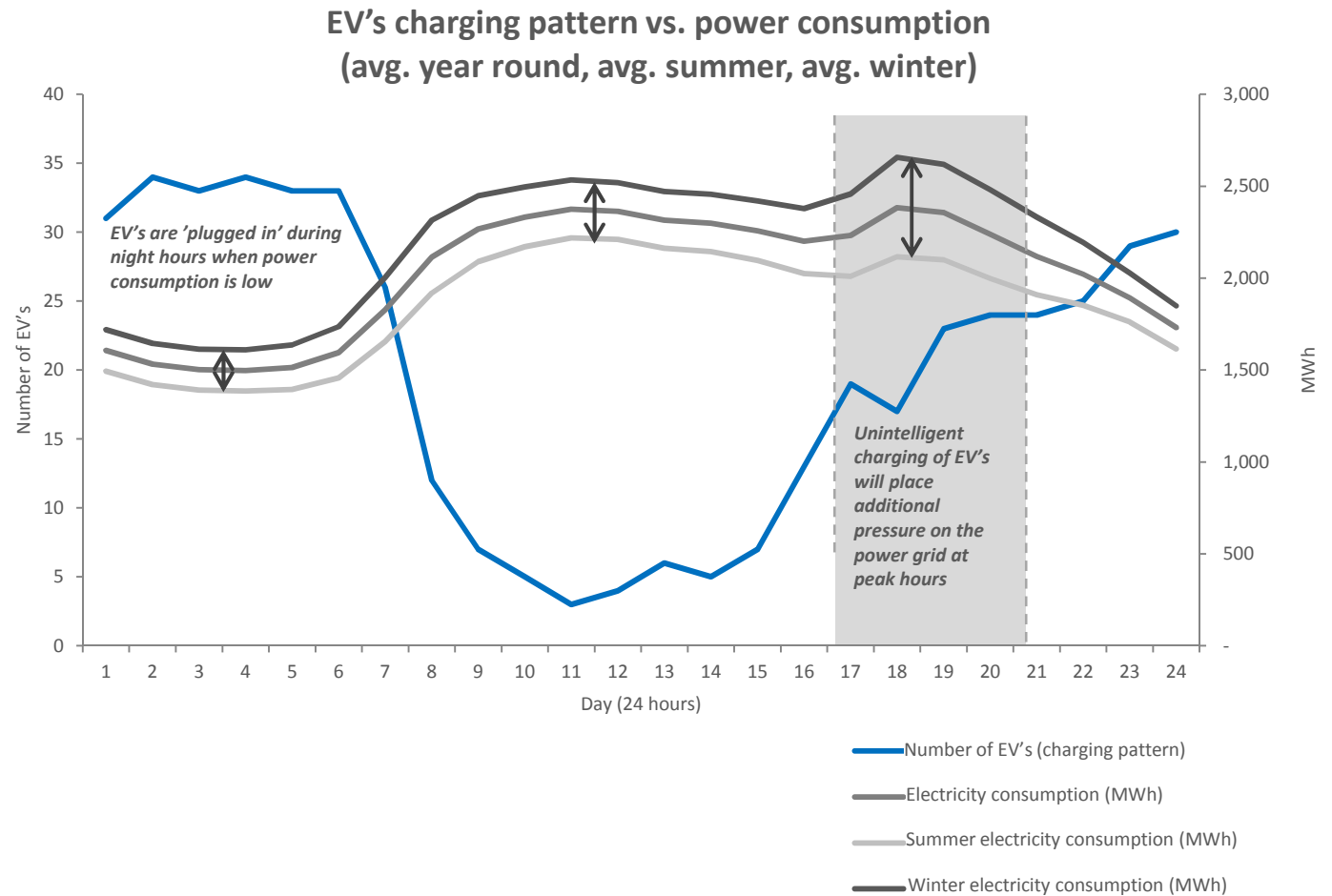


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Along with the gradual emergence of EV's – innovators and entrepreneurs are introducing new and visionary business models



Selling EV's as consumer electronics

- Within consumer electronics - new business models are emerging. Big brands enter the market to establish a strong foothold amongst new alternative transportation and energy management solutions for private consumers.
- EV manufacturers (General Motors, Nissan, Ford and Mitsubishi) have entered partnerships with consumer electronics chain Best Buy and their subsidiary Geeksquad. Best Buy's extensive sales and distribution network are excellent for selling EV's. Geeksquad can help with installation and customer support related to private charging stations.

Locating, booking and sharing charging stations

- Most EV leasing and carpooling services offers a Smartphone application for locating the nearest charging station.
- Coulomb Technologies offers online booking of their charging stations on forehand to avoid possible waiting time.
- PlugShare's business model allows EV users to share their private charging stations with other EV users – through an economic incentive.



Business Models / EV's are sold on subscription

Similarly to mobile phones, EV's are sold on subscription - and rental companies are beginning to include EV's as part of their fleet program



Like mobile phones - EV's are sold on subscription

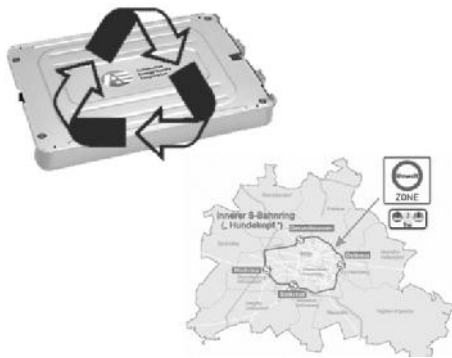
- Fixed subscription - (x number of miles per years) including power consumption = no differential running costs.
- Pay as you go subscription – pay for the number of kilometers traveled (calculated by the onboard navigation system)
- Companies that offer driving subscriptions (including power consumption) will act as a electric mediator between the energy company and the user. Like the mobile phone industry, roaming is also likely to occur in connection with EV's.

Carpooling and rentals

- Zipcar's business model makes it simple, easy and fast to rent a EV for specific purpose. It's a membership model that works as a substitute for owning a car. Many other local companies around the world offer the same service, and lessons from Oslo show, that small firms primarily use EV's during daytime and private people during late afternoon / evening.
- Connect by Hertz is a global initiative to offer EV's as part of their fleet. Hertz has also formed several strategic partnerships with companies and universities around EV's.
- A number of companies facilitate 'peer to peer' hiring and lending of EV's. The phenomenon is mostly found in the U.S. and facilitated by City Car Share, RelayRides, Sprider share and RentMyCar.



EV batteries are reused at power plants to create energy storage capacity, and cities encourage EV's by offering attractive incentives by easing rules and regulations



Recycling batteries for energy storage

- Power plants currently study the opportunities of reusing surpassed EV batteries. One could also imagine this to be relevant for residential and commercial electrical systems.
- Reusing EV batteries could potentially reduce the total cost of EV's, as the battery can be resold. This could potentially also influence a more precise determination of EV's residual value.
- Reselling surpassed EV batteries could potentially lead to new business models where “brokers” shift and trade energy storage capacity.

Environmental Zones

- EU environmental zones (e.g. London, Berlin and Stockholm), offer attractive incentives for EV drivers such as: Free public parking, Allowed to use bus lanes, No road taxes and Free ferry transport. EV manufacturers naturally focus their attention towards these zones.



FedEx already use EV's for package delivery



EV busses in Shenzhen, China

Urban transportation

- EV's are ideal for areas where driving needs can be estimated accurately on a daily basis. Some of these areas are:

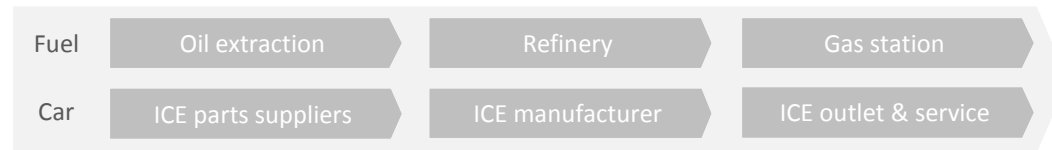
Product Delivery, Package Delivery, Shops / stores (product delivery), Restaurants / cafes (meals on wheels), Home care, Commuting disabled people, Bus transport, Governmental offices (transportation to and from meetings), Companies (transportation to and from meetings), Taxis (primarily urban), Airports (internal transport)

The EV value chain creates opportunities for newcomers to participate and create value on the mobility market – e.g. as integrators or mobility service providers

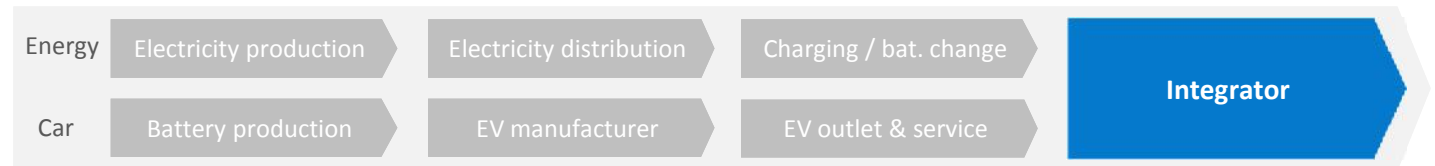
The Integrators are the future industry actors, who will handle the integration between EV charging and the intelligent home regarding billing, etc.

For example, ECotality partnered with Sprint Nextel and Cisco to deliver wireless connectivity for charging stations and home energy management solutions / controllers.

ICE value chain



EV value chain



Example of an integrator

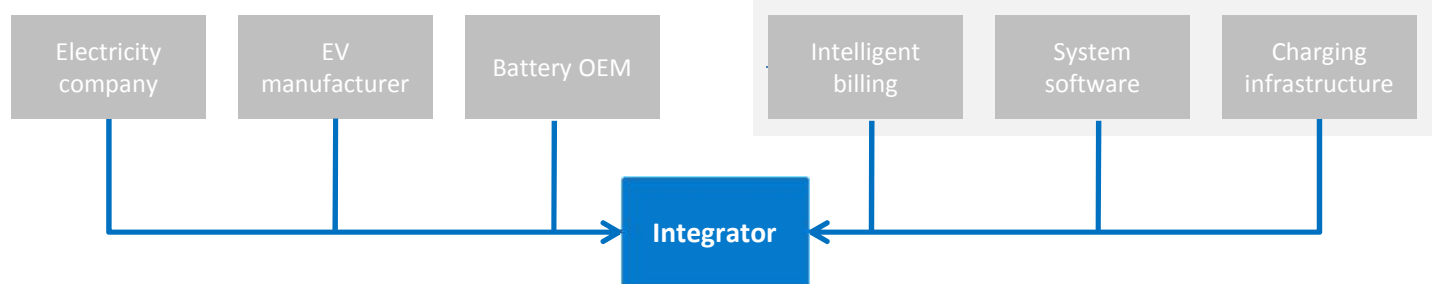


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Conclusion

EV pricing

- EV's are still expensive compared to most alternative ICE vehicles. In fact, for less the price of an EV you can get a equivalent ICE fully "specked" with extra equipment. Pricing therefore is one of the major barriers to spread EV's.
- There is a relatively big price difference between the US, EU and UK (in favor of the US). Most of the price difference is due to difference in VAT, import taxes, regional model variations and shipping costs and dealer margins.
- It seems likely that there will be a significant price erosion related to EV batteries over the next 10 years. This is due to 'scale of production' and tech development. This will most likely reduce EV prices and increase sales.

The value of intelligent fleet management

- Based on data collected from an experiment (involving 37 'small car' EV's - performed over a year (2009 - 2010) - funded by a Danish governmental organization called 'Energistyrelsen') the following is concluded:
- If EV's are not charged "intelligently", there is a risk of EV's having a negative effect on the electrical grid at 'peak hours' where power consumption is at its peak.
- This situation can be avoided by implementing a Smart Grid, combined with the right business / incentive model.
- To avoid excessive infrastructure investments (integrating EV's on the electrical grid) and to better leverage volatile energy (for charging of EV's with green energy) – EV's needs to be 'plugged-in' at all times when parked. Data from the experiment indicates, that this will be a challenge:
 - EV's only 'plugged in' by every fourth parking.
 - EV's used the battery capacity by 35% - leaving 65% in surplus energy at all times. Therefore users have no real incentive to 'plug in' to a charger when parked.

EV financing and EV business models

- Customers perceive EV's as a relatively new and immature technology. Customers are therefore insecure about investing in and purchasing something "new and unproven". Leasing enables consumers to minimize risk by not having to invest and purchase an EV.
- This "new and unproven" EV market also attracts newcomers, who are currently creating new markets through innovative business and financing models.

Observations

Based on data collected from a experiment (involving 37 'small car' EV's - performed over a year (2009 - 2010) - funded by a Danish governmental organization called 'Energistyrelsen') the following is observed:

- On average EV's were charged by 35% per charge. In other words – batteries have a unused capacity of approx. 65% state of charge (SOC).
- EV's has a plentiful energy capacity, sufficient for the daily need of most people.
- By every fourth parking, EV's connected to a charger – and 68% of EV's were charged once daily
- The majority of EV's charged during evening and night hours, during which power consumption and prices were lowest
- Without intelligent charging the majority of EV's would charge between 5 pm and 9 pm - placing significant pressure on the power grid at “peak hours”

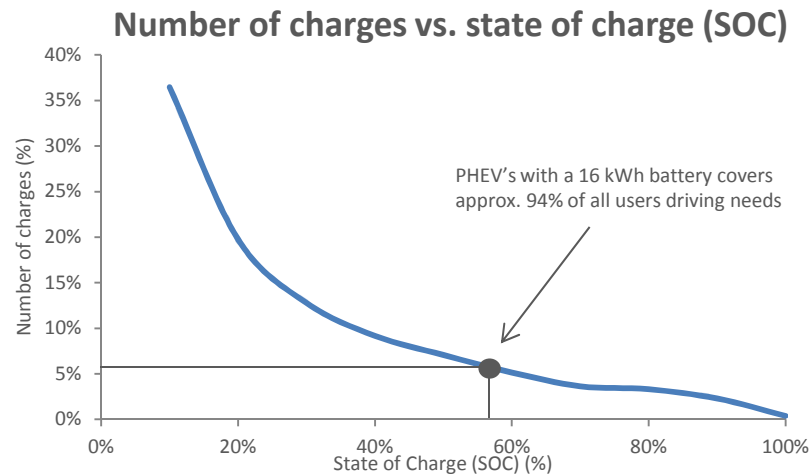
Plug-in hybrids (PHEV's) are better short-term alternatives to EV's considering the limitations related to charging infrastructure

ILLUSTRATIVE

94% of the test fleet drove an average of 33 km per day. In this case, PHEV's could certainly cover the driving needs of the vast majority – just by utilizing their pure electric driving range.

PHEV's like Chevrolet Volt has a battery capacity of 16 kWh, which would cover approx. 94% of all EV test fleet users driving needs.

PHEV's allows for a more rapid roll-out due to unchanged comfort related to driving range and a already existing infrastructure.



Driving Range vs. Charging Time vs. Infrastructure Cost

	ICE	PHEV	EV
Charging Time	5 min	2-3 hours	4-8 hours
Driving Range	600 km	600 km 60 km (electric)	250 km (electric)
Infrastructure	Already existing 100 %	Already existing ~75 %	Under development ~25 %

Smart Grid with 'vehicle-to-grid' (V2G) functionality can potentially accelerate the expansion of EV' - by creating new economic incentives within the EV value chain

ILLUSTRATIVE

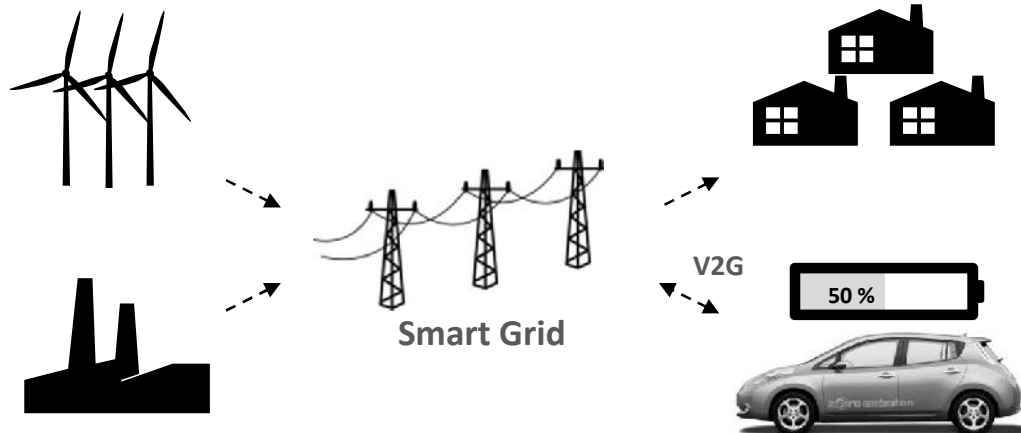
V2G makes it possible to use EV's as a collective and dynamic energy storage capacity.

E.g. when wind turbines produce more energy than needed, EV's could be fully charged, and then deliver energy back to the grid when needed (as an alternative to conventional fossil electricity production).

As an example consider the following hypothetical scenario:

- 200.000 EV's
- Battery size of 24 kWh per car
- DOC of 50%

The 200.000 EV's could then return 2.4 GWh back to the grid when needed, rather than increasing conventional power production.



$$\text{Avoid negative prices*} + \text{Avoid conventional electricity production} = \text{Value of Smart Grid + V2G}$$

About MEC Intelligence

MEC creates insights that are actionable and integrate directly into the client's growth decision processes

MEC Intelligence is a global strategic- and market insights firm specialising in evaluating growth opportunities and industry dynamics in the Maritime, Energy, and Cleantech industries.

With unique market and company intelligence, access to industry experts, and our proprietary analysis approaches, MEC creates insights that are actionable and integrate directly into the client's growth decision processes.

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Catalyst Strategy Consulting is an international consultancy based in Copenhagen, Denmark.

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MEC Intelligence India
MEC Consulting Pvt. Ltd.
Levels 5, 6 and 7
JMD Regent Square
Mehrauli-Gurgaon Road
Gurgaon
India
Tel: +91 9810 53 3550
Email: india@mecintelligence.com

MEC Intelligence Denmark
Nordre Fasanvej 113,2
2000 Frederiksberg.
Copenhagen
Denmark
Tel: +45 3543 3277
Email: europa@mecintelligence.com